Claims

1. A method of processing spread spectrum signals comprising:

receiving a continuous signal (S_{IF}) of a comparatively high frequency,

sampling the continuous signal (S_{IF}) at a basic sampling rate (r_S), whereby a resulting sequence of time discrete signal samples ($S[s_i]$) is produced,

quantising each signal sample into a corresponding level-discrete sample value,

forming of a plurality of data words ($d(1), \ldots, d(N)$) which each includes one or more consecutive sample values ($s_1, \ldots, s_n$), and

correlation between information in the data words ($d(k)$) and at least one representation ($CS(i)$) of a signal source specific code sequence (CS), **characterized by**

the method comprising a preparation for the correlation step, wherein, before receiving the continuous signal (S_{IF}), a multitude of code vectors (CV; CV_m) are pre-generated, each code vector representing a particular code sequence ($CS(i)$) of the at least one signal source specific code sequence (CS), and

the correlation step involving multiplying at least each vector in a sub-group (CV_{m-E}, CV_{m-P}; CV_{m-L}) of the code vectors (CV; CV_m) with at least one vector ($S_{IF-I}(k)$; $S_{IF-Q}(k)$) derived from the data word ($d(k)$).

2. A method according to claim 1, **characterized by** each code vector (CV; CV_m) representing a particular signal source specific code sequence ($CS(i)$) being sampled at the basic sampling rate (r_s) and quantised with the quantising process being used to produce the level-discrete sample values ($s_1, \ldots, s_n$).

3. A method according to any one of the preceding claims, **characterized by** the at least one signal source specific code sequence (CS) being pseudo random noise.

4. A method according to any one of the preceding claims, **characterized by** the receiving step involving down conversion of an incoming high-frequency signal (S_{HF}) to an intermediate frequency signal (S_{IF}), the high-frequency signal (S_{HF}) having a spectrum which is symmetric around a first frequency (f_{HF}) and the intermediate frequency signal (S_{IF}) having a spectrum which is symmetric around a second frequency (f_{IF}) being considerably lower than the first frequency (f_{HF}).

5. A method according to claim 4, **characterized by** the steps of: determining a maximum frequency variation (f_D) of the second frequency (f_{IF}) due to Doppler-effects,

defining a Doppler frequency interval ($f_{IF\text{-}min}$ - $f_{IF\text{-}max}$) around the second frequency (f_{IF}), the Doppler frequency interval ($f_{IF\text{-}min}$ - $f_{IF\text{-}max}$) having a lowest frequency limit ($f_{IF\text{-}min}$) equal to the difference between the second frequency (f_{IF}) and the maximum frequency variation (f_D), and a highest frequency limit ($f_{IF\text{-}max}$) equal to the sum of the second frequency (f_{IF}) and the maximum frequency variation (f_D),

dividing the Doppler frequency interval ($f_{IF\text{-}min}$ - $f_{IF\text{-}max}$) into an integer number of equidistant (Δf) frequency steps ($f_{IF\text{-}min}$, $f_{IF\text{-}min}+\Delta f$, ..., $f_{IF\text{-}max}$), and

defining a frequency candidate vector ($f_{IF\text{-}C}$) for each frequency step ($f_{IF\text{-}min}$, $f_{IF\text{-}min}+\Delta f$, ..., $f_{IF\text{-}max}$).

6. A method according to claim 5, **characterized by** the steps of: determining an integer number of initial phase positions (φ_0, ..., φ_7) for the frequency candidate vector ($f_{IF\text{-}C}$), and

defining a carrier frequency-phase candidate vector ($V_{f\varphi}(f_{IF\text{-}C}, \varphi_C)$) for each combination of carrier frequency candidate vector ($f_{IF\text{-}C}$) and initial phase position (φ_0, ..., φ_7).

7. A method according to claim 6, **characterized by** the steps of: determining the number of elements (s_n) in each carrier frequency-phase candidate vector ($V_{f\varphi}(f_{IF\text{-}C}, \varphi_C)$), and

storing the carrier frequency-phase candidate vector ($V_{f\varphi}(f_{IF-C}, \varphi_C)$) according to a data format being adapted to performing multiplication operations between the data word ($d(k)$) and a segment of a carrier frequency-phase candidate vector ($V_{f\varphi}(f_{IF-C}, \varphi_C)$).

8. A method according to claim 7, **characterized by** the adapting of the data format involving adding at least one element to each segment of the carrier frequency-phase candidate vector ($V_{f\varphi}(f_{IF-C}, \varphi_C)$) such that the segment attains a number of elements which is equal to the number of elements in the data word ($d(k)$), thus enabling a segment of the carrier frequency-phase candidate vector ($V_{f\varphi}(f_{IF-C}, \varphi_C)$) and one of the at least one vector ($S_{IF-I}(k)$; $\hat{S}_{IF-Q}(k)$) to be processed jointly by at least one of a SIMD-operation and an XOR-operation.

9. A method according to any one of the preceding claims, **characterized by** the steps of:

determining a maximum variation a code rate due to Doppler-effects,

defining a Doppler rate interval ($CR_{C-min} - CR_{C-max}$) around a center code rate (CR_C), the Doppler frequency interval having a lowest code rate limit (CR_{C-min}) equal to the difference between the center code rate (CR_C) and the maximum code rate variation (CR_D), and a highest frequency limit (CR_{C-max}) equal to the sum of the center code rate (CR_C) and the maximum code rate variation (CR_D),

dividing the Doppler rate interval ($CR_{C-min} - CR_{C-max}$) into an integer number of equidistant (ΔCR) code rate steps (CR_{C-min}, $CR_{C-min}+\Delta CR$, ..., CR_{C-max}) and

defining a code rate candidate (CR_{C-C}) for each code rate step (CR_{C-min}, $CR_{C-min}+\Delta CR$, ..., CR_{C-max}).

10. A method according to claim 9, **characterized by** determining an integer number of possible initial code phase positions

(0.0, ..., 0.9) for each code rate candidate (CR_{C-C}).

11. A method according to claim 10, **characterized by** defining, for each signal source specific code sequence (CS(i)), a set of combinations between code rate candidate (CR_{C-C}) and code phase position (0.0, ..., 0.9), each combination representing a code rate-phase candidate vector.

12. A method according to claim 11, **characterized by** generating, for each signal source specific code sequence (CS(i)), a set of code vectors (CV) by:

sampling each code rate-phase candidate vector with the basic sampling rate (r_S) whereby a corresponding code vector (CV) is produced.

13. A method according to any one of the preceding claims, **characterized by** generating a modified code vector (CV_m) on basis of each code vector (CV) by:

copying a particular number of elements (E_e) from the end of an original code vector (CV) to the beginning of the modified code vector (CV_m), and

copying the particular number of elements (E_b) from the beginning of the original code vector (CV) to the end of the code vector (CV_m).

14. A method according to claim 13, **characterized by** storing, for each signal source specific code sequence (CS(i)), a set of modified code vectors ({CV_m(CR_{C-C}, Cph)}), where

each modified code vector (CV_m) contains a number of elements (s_1, ..., s_m) representing a sampled version of at least one full code sequence (CS),

a particular modified code vector (CV_m) is defined for each combination of code rate candidate (CR_{C-C}) and code phase position (Cph).

15. A method according to claim 14, **characterized by** adapting the data format of the modified code vectors (CV_m) with respect to the data format of the at least one vector ($S_{IF-I}(k)$; $S_{IF-Q}(k)$) derived from the data word ($d(k)$), such that a modified code vector (CV_m) and one of the at least one vector ($S_{IF-I}(k)$; $S_{IF-Q}(k)$) may be processed jointly by at least one of a SIMD-operation and an XOR-operation.

16. A method according to any one of the claims 14 or 15, **characterized by** involving an initial acquisition phase and a subsequent tracking phase, wherein during the acquisition phase a set of preliminary parameters are established which are required for initiating a decoding of signals received during the tracking phase, a successful acquisition phase resulting in at least one signal source specific code sequence (CS) being identified and a transmitted signal being rendered possible to track, each of the at least one signal source specific code sequence (CS) being associated with tracking characteristics in the form of:

a modified code vector (CV_m),

a carrier frequency candidate vector (f_{IF-C}),

an initial phase position (φ_C),

a code phase position (Cph), and

a code index (CI) denoting a starting sample value for the modified code vector (CV_m).

17. A method according to claim 16, **characterized by** the tracking involving:

calculating, based the tracking characteristics, a prompt pointer (P_P) for each modified code vector (CV_m), the prompt pointer (P_P) indicating a code sequence start position, and an initial prompt pointer (P_P) being equal to the code index (CI), and

assigning, around each prompt pointer (P_P), at least one pair of early- and late pointers (P_E, P_L; P_{E1}, P_{L1} P_{E2}, P_{L2}), where the early pointer (P_E) specifies a sample value being positioned at least one element before the prompt pointer's (P_P) position,

and the late pointer (P_L) specifies a sample value being positioned at least one element after the prompt pointer's (P_P) position.

18. A method according to claim 17, **characterized by** the tracking involving:

receiving a sequence of incoming level-discrete sample values (1210),

forming data words (d(1), ..., d(N)) of the sample values (1210) such that each data word (d(k)) contains a number of elements which is equal to the number of elements (s_n) in each carrier frequency-phase candidate vector ($V_{f\varphi}(f_{IF-C}, \varphi_C)$),

calculating a relevant set of carrier frequency-phase candidate vectors ($V_{f\varphi}(f_{IF-C}, \varphi_C)$) for the data word (d(k)), and

acquiring, for each carrier frequency-phase candidate vector ($V_{f\varphi}(f_{IF-C}, \varphi_C)$) in the relevant set, a pre-generated in-phase representation (f_{IFI}) and a quadrature-phase representation (f_{IFQ}) of the vector ($V_{f\varphi}(f_{IF-C}, \varphi_C)$) respectively.

19. A method according to claim 18, **characterized by** the tracking involving:

multiplying each data word (d(k)) with the in-phase representation (f_{IFI}) of the carrier frequency-phase candidate vector ($V_{f\varphi}(f_{IF-C}, \varphi_C)$) in the relevant set to produce a first intermediate-frequency-reduced information word ($S_{IF-I}(k)$),

multiplying each data word (d(k)) with the quadrature-phase representation (f_{IFQ}) of the carrier frequency-phase candidate vector ($V_{f\varphi}(f_{IF-C}, \varphi_C)$) in the relevant set to produce a second intermediate-frequency-reduced information word ($S_{IF-Q}(k)$).

20. A method according to claim 19, **characterized by** the tracking involving:

multiplying the first intermediate-frequency-reduced information word ($S_{IF-I}(k)$) with a modified code vector ($CV_{m-P}(k)$) starting at a position indicated by the prompt pointer (P_P) to

produce a first prompt-despread symbol string ($\Lambda_{IP}(k)$),

multiplying the first intermediate-frequency-reduced information word ($S_{IF-I}(k)$) with a modified code vector ($CV_{m-E}(k)$) starting at a position indicated by an early pointer (P_E) to produce a first early-despread symbol string ($\Lambda_{IE}(k)$),

multiplying the first intermediate-frequency-reduced information word ($S_{IF-I}(k)$) with a modified code vector ($CV_{m-L}(k)$) starting at a position indicated by a late pointer (P_L) to produce a first late-despread symbol string ($\Lambda_{IL}(k)$),

multiplying the second intermediate-frequency-reduced information word ($S_{IF-Q}(k)$) with a modified code vector ($CV_{m-P}(k)$) starting at a position indicated by the prompt pointer (P_P) to produce a second prompt-despread symbol string ($\Lambda_{QP}(k)$),

multiplying the second intermediate-frequency-reduced information word ($S_{IF-Q}(k)$) with a modified code vector ($CV_{m-E}(k)$) starting at a position indicated by the early pointer (P_E) to produce a second early-despread symbol string ($\Lambda_{QE}(k)$), and

multiplying the second intermediate-frequency-reduced information word ($S_{IF-Q}(k)$) with a modified code vector ($CV_{m-L}(k)$) starting at a position indicated by the late pointer (P_L) to produce a second late-despread symbol string ($\Lambda_{QL}(k)$).

21. A method according to claim 20, **characterized by** the tracking involving deriving, for each despread symbol string, a resulting data word ($D_{R-IP}(k)$, $D_{R-IE}(k)$, $D_{R-IL}(k)$, $D_{R-QP}(k)$, $D_{R-QE}(k)$; $D_{R-QL}(k)$).

22. A method according to claim 21, **characterized by** deriving the resulting data words ($D_{R-IP}(k)$, $D_{R-IE}(k)$, $D_{R-IL}(k)$, $D_{R-QP}(k)$, $D_{R-QE}(k)$; $D_{R-QL}(k)$) by looking up a respective pre-generated value in a table (1310).

23. A method according to any one of the claims 19 - 22, **characterized by** performing the multiplication between the data word ($d(k)$) and the in-phase representation (f_{IFI}) of the carrier frequency-phase candidate vector ($V_{f\varphi}(f_{IF-C}, \varphi_C)$) respective between the data word ($d(k)$) and the a quadrature-phase representation (f_{IFQ}) of the carrier frequency-phase candidate vector ($V_{f\varphi}(f_{IF-C}, \varphi_C)$) by means of at least one of a SIMD-operation and an XOR-operation

24. A method according to any one of the claims 19 - 23, **characterized by** performing the multiplication between the intermediate-frequency-reduced information words ($S_{IF-I}(k)$; $S_{IF-Q}(k)$) and the modified code vectors (CV_{m-P}, CV_{m-E}; CV_{m-L}) by means of at least one of a SIMD-operation and an XOR-operation.

25. A method according to any one of the claims 19 - 24, **characterized by** propagating, in connection with completing the processing of a current data word ($d(k)$) and initiating the processing of a subsequent data word ($d(k+1)$):

a pointer (p_d) indicating a first sample value of the subsequent data word ($d(k+1)$),

a group of parameters describing the relevant set of carrier frequency-phase candidate vectors ($V_{f\varphi}(f_{IF-C}, \varphi_C)$),

the relevant set of code vectors (CV_m), and

prompt-, early-, and late pointers (P_P, P_E, P_L).

26. A computer program directly loadable into the internal memory of a computer, comprising software for controlling the steps of any of the claims 1 – 25 when said program is run on the computer.

27. A computer readable medium, having a program recorded thereon, where the program is to make a computer control the steps of any of the claims 1 – 25.

28. A signal receiver (1500) for receiving navigation data signals transmitted in a navigation satellite system comprising:

a radio front end unit (1510) adapted to receive a continuous radio signal (S_{HF}) and in response thereto produce a corresponding electrical signal (S_{IF}) comparatively high frequency,

an interface unit (1520) adapted to receive the electrical signal (S_{IF}) and in response thereto produce a sequence of sample values being divided into data words (d(k)), and

a digital processor unit (1530) adapted to receive the data words (d(k)) and in response thereto demodulate a data signal, and including a memory means (1535), **characterized in that** a computer program according to claim 26 is loaded into the memory means (1535).